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Yukiko Iwata
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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of)
)
EDUARD C. BRAS and)
PARAMASIVAM S. KUMAR)
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Serial No. 10/774,741)
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Filed February 9, 2004)
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REMOVING NATURAL GAS LIQUIDS FROM) June 16, 2004
A GASEOUS NATURAL GAS STREAM)
)

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CLAIM TO PRIORITY

Applicants reaffirm the claim for the benefit of filing date of the following foreign patent application referred to in Applicants' Declaration:

European application Serial No. 03250826.9 filed February 10, 2003

A copy of the application certified by the European Patent Office is enclosed.

Respectfully submitted,

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Bescheinigung | Certificate | Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr. | Patent application No. | Demande de brevet n°

03250826.9

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

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Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Removing LPG-components from a gaseous natural gas stream

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REMOVING LPG-COMPONENTS FROM A GASEOUS NATURAL GAS STREAM

The present invention relates to removing LPG-components from a gaseous natural gas stream. In the specification and the claims the term LPG-components is used to refer to those gaseous hydrocarbons that can be liquefied under relatively low pressure and at ambient temperature. Examples of LPG-components are propane and the butanes. These components are sometimes called natural gas liquids.

The LPG-components are removed, because they have an economic value and because removing the LPG-components reduces the heating value of the natural gas stream.

By way of example we give a molar composition of a natural gas stream from which the LPG-components are to be removed: methane 86 mol%, ethane 6 mol%, propane 4 mol%, butane plus 1 mol%, and the balance is formed by other components, such nitrogen, carbon dioxide and helium.

The present invention relates in particular to removing such LPG-components from a natural gas stream at elevated pressure, for example at pressures greater than 3 MPa and less than the critical pressure of the natural gas, which is about 7 MPa.

A method for removing LPG-components from a natural gas stream is disclosed in USA patent specification No. 5 325 673. This publication discloses a method of pre-treating a natural gas stream for liquefaction by removing freezable components, comprising the steps of:

a) introducing a natural gas feed stream into a scrub column having upper enriching and lower stripping sections;

b) contacting the feed stream with a liquid reflux stream introduced into the upper enriching section of the column to absorb C_5^+ hydrocarbons from the feed stream;

c) recovering an overhead vapour product containing C_2-C_4 hydrocarbons and having a concentration of less than about 1 ppm C_6^+ hydrocarbons;

d) reboiling a portion of liquid in the lower section of the column to strip lighter hydrocarbons from the feed stream;

e) recovering a liquid bottom product enriched in C5+ hydrocarbons; and

f) operating the column to obtain the C_2-C_4 hydrocarbons primarily in the overhead product.

The known process is directed to obtaining an overhead product that has a very low concentration of C_6^+ hydrocarbons, however, the overhead product still contains considerable amounts of ethane, propane and butanes.

The present invention provides a method for removing LPG-components from a gaseous natural gas stream wherein high-pressure separation is obtained, which has a high propane recovery and a high rejection of methane and ethane. Moreover it is an object of the present invention to provide a method of removing LPG-components in which no reboiler is needed.

To this end the method of removing LPG-components from a gaseous natural gas stream at elevated pressure to obtain a gaseous product stream having a reduced content of LPG-components according to the present invention comprises the steps of:

(a) cooling the natural gas stream;

(b) introducing the cooled natural gas stream into the bottom of a scrub column that has a lower stripping section and an upper absorption section, each section containing at least one theoretical stage;

(c) allowing natural gas to rise through the scrub column, and removing from the top of the scrub column an overhead stream;

(d) partly condensing the overhead stream, and separating the partly condensed overhead stream into a gaseous stream having a reduced content of LPG-components and a liquid reflux stream, and removing the gaseous stream as the gaseous product stream having a reduced content of LPG-components;

(e) splitting the liquid reflux stream into a first reflux stream and a second reflux stream;

(f) introducing the first reflux stream into the top of the absorption section of the scrub column;

(g) introducing the second reflux stream into the top of the stripping section to strip the desired light gaseous components; and

(h) removing from the bottom of the scrub column a liquid bottom stream rich in heavier components.

Suitably the method according to the present invention further comprises introducing hydrocarbon liquid into the top of the absorption section.

The invention will now be described by way of example in more detail with reference to the accompanying drawing, which shows schematically a flow scheme of the method according to the present invention.

A gaseous natural gas stream including LPG-components, which is essentially free from acid gases, is supplied via conduit 1 to a heat exchanger 2 in which the stream is partly condensed. Partly condensed natural gas is supplied through conduit 3 into the bottom of a scrub column 6. The pressure of the natural gas entering into the scrub column is between 3 and about 7 MPa, and the temperature is between 0 and -20 °C.

The scrub column 6 operates at the pressure at which the natural gas is supplied. The scrub column 6 comprises

two sections, a lower stripping section 7 and an upper absorption section 8 separated from the stripping section 7 by an interval 9. The stripping section 7 comprises between 1 and 4 theoretical stages and the absorption section 8 comprises between 4 and 10 theoretical stages. The theoretical stages can be provided by contacting trays or by a suitable packing material.

The gaseous fraction of the natural gas stream is allowed to rise in the scrub column 6 through the stripping section 7 and the absorption section 8. The liquid fraction of the natural gas stream is removed from the scrub column 6 through a conduit 10.

From the top of the scrub column 6 is removed through conduit 12 an overhead stream having a reduced content of LPG-components. The overhead stream is partly condensed in heat exchanger 14, and separated in separation vessel 17 into a liquid stream and a gaseous product stream. The gaseous product stream is removed from the separation vessel 17 through conduit 20 and passed to a plant for liquefying the gaseous product stream (not shown). The liquid stream is removed through conduit 21. The temperature of the partly condensed overhead stream is in the range of from -25 to -65 °C, and the amount of liquid in the partly condensed overhead stream is between 10 and 35 mol% based on the total overhead stream.

Part of the liquid stream is introduced through conduit 22 as a first reflux stream into the top of the scrub column 6 above the absorption section 8 as an absorbent. The liquid is brought in the absorption section 8 in counter-current contact with the gas from the stripping section 7. Components heavier than methane are removed from the gas by the first reflux stream acting as an absorbent.

The remainder of the liquid stream is introduced through conduit 23 as a second reflux stream into the scrub column 6 in the interval 9 above the stripping section 7. In the stripping section 7, the second reflux stream and the liquid descending from the absorption section 8 are brought into counter-current contact with the rising gaseous fraction of the natural gas stream. The gaseous fraction strips the light components (methane and ethane) from the liquid stream. The liquid stream having a low concentration of light components is then removed from the bottom of the scrub column 6 through conduit 10.

Suitably, the amount of second reflux stream in the conduit 23 is between 30 and 50 % by mass of the liquid stream that is removed from the separator vessel 17.

In addition hydrocarbon liquid can be introduced into the top of the absorption section 8 through conduit 25. The amount of this additional absorbent is suitably between 1 and 4 times the amount of liquid supplied through conduit 22. The additional absorbent suitably consists of butane plus components.

Suitably, the liquid bottom stream removed through conduit 10 is introduced into the top of a stripping column (not shown) to strip gaseous components from the liquid bottom stream. The stripped gaseous components can be added to the gaseous product stream.

The invention will now be described by way of example with reference to three calculated examples. In the first example, not according to the present invention, only the reflux through conduit 22 is supplied to the top of the scrub column 6. In the second example, according to the present invention, reflux is supplied through conduits 22 and 23; and in the third example, according to the present invention, additional hydrocarbon liquid is supplied through conduit 25. The conditions for each

example have been so selected as to maximize the recovery of LPG-components.

In the examples, the scrub column contains eight theoretical stages. In the two examples according to the present invention, the stripping section 7 contains two theoretical stages and the absorption section 8 contains six theoretical stages.

The results are summarized in the below Tables 1-8.

In the tables the molar flow rates are in kmol/s, the mass flow rates are in kg/s, the temperatures are in °C, the pressures are in MPa (absolute); and the molar composition is in mol%. The butane plus components are butane, iso-butane, pentane, iso-pentane, hexane and heptane. The other components mentioned in the composition are water, nitrogen, hydrogen sulphide, carbon dioxide and helium.

Table 1. Data on partly condensed feed supplied through conduit 3.

Stream 3	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	7.90	7.55	7.73
Mass flow rate	155	142	145
Temperature	0	-5	-5
Pressure	5.6	5.8	6.0
Molar composition			
Methane	0.862	0.882	0.882
Ethane	0.064	0.062	0.062
Propane	0.042	0.036	0.036
Butane plus	0.031	0.019	0.019
Other components	Balance	Balance	Balance

Table 2. Data on overhead stream removed from top of the scrub column through conduit 12. Please note that the flow rates are larger than the flow rates in conduit 3, because of the internal recycle.

Stream 12	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	8.79	8.64	8.39
Mass flow rate	168	161	152
Temperature	-19	-23	-18
Pressure	5.6	5.6	6.0
Molar composition			
Methane	0.852	0.871	0.897
Ethane	0.080	0.078	0.070
Propane	0.064	0.043	0.022
Butane plus	0.003	0.006	0.001
Other components	Balance	Balance	Balance

Table 3. Data on reflux supplied through conduit 22 to top of the scrub column 6.

Stream 22	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	1.57	0.17	0.08
Mass flow rate	40.5	4.05	1.81
Temperature	-43	-48	-54
Pressure	5.6	5.8	6.0
Molar composition			
Methane	0.571	0.650	0.720
Ethane	0.176	0.170	0.155
Propane	0.241	0.152	0.078
Butane plus	0.001	0.027	0.005
Other components	Balance	Balance	Balance

Table 4. Data on reflux supplied through conduit 23 to top of the stripping section 7 in the scrub column 6.

Stream 23	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	Not applicable	1.54	1.46
Mass flow rate	Not applicable	3.68	3.31
Temperature	Not applicable	-48	-54
Pressure	Not applicable	5.8	6.0
Molar composition			
Methane	Not applicable	0.650	0.720
Ethane	Not applicable	0.170	0.155
Propane	Not applicable	0.152	0.078
Butane plus	Not applicable	0.027	0.005
Other components	Not applicable	Balance	Balance

Table 5. Data on hydrocarbon liquid supplied through conduit 25 to top of the scrub column 6.

Stream 25	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	Not applicable	Not applicable	0.12
Mass flow rate	Not applicable	Not applicable	7.9
Temperature	Not applicable	Not applicable	-33
Pressure	Not applicable	Not applicable	6.0
Molar composition			
Methane	Not applicable	Not applicable	0.00
Ethane	Not applicable	Not applicable	0.00
Propane	Not applicable	Not applicable	0.00
Butane plus	Not applicable	Not applicable	1.00
Other components	Not applicable	Not applicable	0.00

Table 6. Data on the gaseous product stream removed through conduit 20.

Stream 20	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	7.196	6.927	6.852
Mass flow rate	128	120	109
Temperature	-43	-49	-54
Pressure	5.3	5.5	5.7
Molar composition			
Methane	0.913	0.925	0.937
Ethane	0.059	0.055	0.051
Propane	0.026	0.017	0.009
Butane plus	0.0009	0.0011	0.0015
Other components	Balance	Balance	Balance

Table 7. Data on liquid fraction of the feed gas that is removed from the bottom of the scrub column 6 through conduit 10.

Stream 10	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Molar flow rate	0.70	0.63	0.99
Mass flow rate	27	22	36
Temperature	-2	-11	-10
Pressure	5.6	5.8	6.0
Molar composition			
Methane	0.343	0.401	0.401
Ethane	0.108	0.133	0.133
Propane	0.208	0.255	0.218
Butane plus	0.341	0.210	0.247
Other components	Balance	Balance	Balance

The results can be summarized in Table 8 by comparing the content of hydrocarbons in the liquid stream that is removed from the bottom of the scrub column 6 through conduit 10.

Table 8. Composition of the liquid stream removed through conduit 10, in per cent of the composition of the feed supplied through conduit 1 (taking into account the absorption liquid supplied through conduit 25 in the last example).

Stream 10	Example 1, Not according to the invention	Example 2, According to the invention	Example 3, According to the invention
Methane	3.5	3.8	5.8
Ethane	15	18	27
Propane	44	59	78
Butane plus	97	93	94

The above results illustrate the advantageous effect on the recovery of LPG-components of separating the reflux stream into two reflux streams, a first reflux stream being supplied to the top of the scrub column 6 and a second reflux stream being supplied to the top of the stripping section 7.

C L A I M S

1. Method of removing LPG-components from a gaseous natural gas stream at elevated pressure to obtain a gaseous product stream having a reduced content of LPG-components, which method comprises the steps of:

(a) cooling the natural gas stream;

(b) introducing the cooled natural gas stream into the bottom of a scrub column that has a lower stripping section and an upper absorption section, each section containing at least one theoretical stage;

(c) allowing natural gas to rise through the scrub column, and removing from the top of the scrub column an overhead stream;

(d) partly condensing the overhead stream, and separating the partly condensed overhead stream into a gaseous stream having a reduced content of LPG-components and a liquid reflux stream, and removing the gaseous stream as the gaseous product stream having a reduced content of LPG-components;

(e) splitting the liquid reflux stream into a first reflux stream and a second reflux stream;

(f) introducing the first reflux stream into the top of the absorption section of the scrub column;

(g) introducing the second reflux stream into the top of the stripping section to strip the desired light gaseous components; and

(h) removing from the bottom of the scrub column a liquid bottom stream rich in heavier components.

2. The method according to claim 1, which method further comprises introducing hydrocarbon liquid into the top of the absorption section.

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A B S T R A C T

REMOVING LPG-COMPONENTS FROM A GASEOUS NATURAL GAS STREAM

Removing LPG-components from a gaseous natural gas stream at elevated pressure to obtain a gaseous product stream having a reduced content of LPG-components comprises:

(a) introducing cooled natural gas (3) into a scrub column (6) that consists of a lower stripping section (7) and an upper absorption section (8);

(b) removing from the scrub column an overhead stream (12);

(c) partly condensing (14) the overhead stream (12), and separating (17) the partly condensed overhead stream into a gaseous product stream (20) and a liquid reflux stream (21);

(d) splitting the liquid reflux stream (21) into a first reflux stream (22) and a second reflux stream (23);

(e) introducing the first reflux stream (22) into the top of the absorption section (8) of the scrub column (6); and

(f) introducing the second reflux stream (23) into the top of the stripping section (7), and removing from the bottom of the scrub column (6) a liquid bottom stream (10) rich in heavier components.

(Figure)

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